FAA-E-2689a
NOTICE-1
June 18, 1990

U.S. Department of Transportation

Federal Aviation Administration

Specification

DUAL MODE

HIGH INTENSITY APPROACH LIGHTING SYSTEM

(ALSF-2/SSALR)

Specification Change Notice (SCN)

1. Originator Name and Address	2.	3. Code Ident	4. Spec No.
Clesson McDonald, ANN-140	☐ Proposed ☒ Approved	5. Code Ident	FAA-E-2689a 6. SCN No. 1

7. System Designation	8. Related ECP/NCP No.	9. Contract No.	10. Procuring Activity
ALSF-2/SSALR	N12306; N12892		

11. Configuration Item Nomenclature	12. Effectivity
8.4	June 18, 1990

This notice informs recipients that the specification identified by the number (and revision letter) shown in block 4 has been changed. The pages changed by this SCN (being those furnished herewith) carry the same date as this SCN. The page numbers and dates listed below in the summary of changed pages, combined with nonlisted pages of the original issue of the revision shown in block 4, constitute the current version of this specification.

13. SCN No.	14. Pages Changed (Indicate Deletions)	S*	A*	15. Date
1	1	X		6/18/90
	2	X		6/18/90
	2a		X	6/18/90
	2b		X	6/18/90
	3	X		6/18/90
	4	X		6/18/90
	5	X		6/18/90
	6	X		6/18/90
	6a		X	6/18/90
	6b		X	6/18/90
	7	X		6/18/90
	8	X		6/18/90
	8a		X	6/18/90
	8b		X	6/18/90
	9	X		6/18/90
	10	X		9/13/83
	11	X		9/13/83
	12	X		9/13/83
	13	X		9/13/83
	14	X		6/18/90
	14a		X	6/18/90
	14b		X	6/18/90
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	16	X		6/18/90
	16a		X	6/18/90
	16b		X	6/18/90

16. Technical Concurrence	17. Date
Veronica C. Jordan, Acting Associate Program Manager for Engineering, ANN-140	2/21/91

*"S" Indicates Supercedes Earlier Page; "A" Indicates Added Page

13.SCN No.	14.Pages Changed (Ind. Del.)	S*	A*	15.Date
1 Cont'	17	X		6/18/90
	18	X		6/18/90
	18a		X	6/18/90
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	19	X		6/18/90
	20	X		6/18/90
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1 Cont'	51	X		6/18/90
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	76b		X	6/18/90

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13.SCN No.	14.Pages Changed (Ind. Del.)	S*	A*	15.Date
1 Cont'	81	X		9/13/83
	82	X		6/18/90
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	88q		X	6/18/90
	88r		X	6/18/90

16.Technical Concurrence	17.Date

* "S" indicates supercedes earlier page; "A" indicates add page

FAA-E-2689a
September 13, 1983
SUPERSEDING
FAA-E-2689,
dated July 24, 1978

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

SPECIFICATION

DUAL MODE HIGH INTENSITY APPROACH LIGHTING SYSTEM (ALSF-2/SSALR)

1. SCOPE

1.1 Scope.- This specification sets forth the integrated system equipment requirements for a Dual Mode High Intensity Approach Lighting System used to present visual approach lighting patterns to landing aircraft on selected Category II/III Runways. This system will have two operational modes, a High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) and a Simplified Short Approach Lighting System with Runway Alignment Indicator Lights (SSALR). This specification sets forth the integration requirements for the entire system, provides detailed requirements for the electrical equipment necessary to energize and remotely control the lighting patterns, provides requirements for remote maintenance monitoring, and provides brief descriptions and interface data for subelements of the system that are procured by other detailed specifications.

1.2 Classification.- Two types of dimmable sequenced flashing lights are covered by this specification.

Type I - Elevated flasher assembly (3.2.5.3)

Type II - Semiflush flasher assembly (3.2.5.4)

1.3 Definitions.- The following definitions apply for this specification.

1.3.1. Mode ALSF-2.- ALSF-2 is an abbreviation for the High Intensity Approach Lighting System with Sequenced Flashing Lights, Category II. In ALSF-2 mode, approximately 100 lamps of the 300 or 500 watt type (35 kilowatts (kw)) are connected in series in each of three constant current loops (FAA Drawing D-6238-4). Actual number of lamps and lamp wattage may vary for each loop.

1.3.2 Mode SSALR.- SSALR is an abbreviation for the Simplified Short Approach Lighting System with Runway Alignment Indicator Lights. In this mode, approximately 20 to 31 lamps of the 300 or 500 watt type (62kW) are connected in series in each of three constant current loops.

1.3.3 Current loop.- A current loop is formed by electrically connecting lamp transformers and an approach lighting system (ALS) regulator in series such that the ALS regulator current has a single path through primary windings of all lamp transformers and hence produces equal illumination of all lamps connected to the respective secondary windings.

1.3.4 Discrimination ratio.- Discrimination ratio is the ratio of specified mean time between failures (MTBF) to the minimum acceptable MTBF.

1.3.5 Down-link.- Data transmission from the air traffic control tower to the substation.

1.3.6 Up-link.- Data transmission from the substation to the air traffic control tower.

1.3.7 Alternating current and voltage.- Unless otherwise specified, all alternating currents and voltages shall be understood to be root-mean-square (rms) values.

1.3.8 High voltage.- Any voltage above 500 volts (V) rms.

1.3.9 Equipment failures.- Equipment failures are black box, module, card, or part failures whose impact upon the system functions may vary from a minor maintenance action to catastrophic. For example, the failure of a power supply whose redundant unit takes over automatically with no system downtime is only an equipment failure.

1.3.10 Failure condition.- A failure condition exists when one or more steady burning lamps or flasher lamps fail after a caution condition.

1.3.11 Functional failures.- Failures which cause either the complete or partial loss of a function.

1.3.12 Caution condition.- A caution condition exists when two steady burning lamps fail while in the SSALR mode or five lamps fail while in the ALSF-2 mode, in any of three current loops. Caution also exists when one flasher fails in the SSALR mode or two flashers fail in the ALSF-2 mode.

1.3.13 TTL compatible.- TTL is an abbreviation for transistor-transistor logic. The input and output shall be either logic high or logic low.

<u>1.3.13.1 Logic high</u>.- Unless otherwise specified, logic high shall be voltage higher than 2.4 volts direct current (dc) but not greater than 5.5 volts dc. It may also be defined by the numeral "1" or "HI".

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1.3.13.2 Logic Low.- Unless otherwise specified, logic low shall be voltage higher than -0.6 volts dc but not to exceed 1 volt dc. It may also be defined by the numeral "0" or "LO".

1.3.14 Complementary metal-oxide semiconductor (CMOS) logic

1.3.14.1 Logic high.- Logic high shall be voltage higher than 9.5 volts dc but not greater than 15 volts dc. It may also be defined by the numeral "1" or "HI".

1.3.14.2 Logic low.- Logic low shall be voltage higher than -0.5 volts but not to exceed 3.6 volts dc. It may also be defined by the numeral"0" or "LO".

1.3.15 24-volt logic

1.3.15.1 Logic high.- Logic high shall be voltage equal or higher than 15 volts dc but not greater than 28 volts dc. It may also be defined by the numeral "1" or "HI".

1.3.15.2 Logic low.- Logic low shall be voltage equal or higher -0.5 volt dc but not to exceed 5 volts dc. It may also be defined by the numeral "0" or "LO".

1.3.16 Mean time between failures (MTBF).- MTBF is equal to the total operating hours of the equipment divided by the number of failures.

1.3.17 Mean time to repair (MTTR).- MTTR is the total corrective maintenance time divided by the total number of corrective maintenance actions.

1.3.18 Predicted MTBF.- The predicted MTBF is determined by reliability prediction methods based on the equipment design, the use environment,and the exponential distribution.

1.3.19 Predicted MTTR.- The predicted MTTR is determined by maintainability prediction methods based ont he equipment design, configuration, fault detection, and fault isolation techniques.

1.3.20 Specified mean time between failures.- The specified MTBF is the minimum acceptable MTBF, times the discrimination ratio.

2. APPLICABLE DOCUMENTS

2.1 FAA documents.- The following FAA specifications, drawings, and standards of the issues specified in the invitation-for bids, or request-for-proposals form a part of this specification to the extent specified herein:

FAA-D-2494	Technical Instruction Book Manuscript: Electronic, Electrical, and Mechanical Equipment, Requirements for Preparation of Manuscript and Production of Books
FAA-E-982	PAR-56 Lampholder; NOTICE-1, dated 2/4/91

2.1.1 FAA specifications

FAA-E-1100	Photometric Test Procedures for Condenser Discharge Lamp
FAA-E-1315	Light Base and Transformer Housing
FAA-E-2408	Lamps, PAR-56 Incandescent, Aviation Services
FAA-E-2491	Approach Light, Semiflush, Steady Burning
FAA-E-2604	Low-Impact Resistance Structure for Medium Intensity Approach Lighting System (MALS)
FAA-E-2690	Isolation Transformer for Approach Lighting System (1500 Watt)
FAA-E-2702	Low Impact Resistance Structure
FAA-G-2100	Electronic Equipment, General Requirement
AC 150/5345-47	Isolation Transformers for Airport Lighting Systems

2.1.2 FAA drawings

C-6046	Frangible Coupling, Type 1 and 1A, Details
D-5140-2	Type JB Junction Box
D-6238-4	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2), Dual Mode Field Lighting Schematic Diagram
D-6238-6	High Intensity Approach Lighting System with Sequenced Flashing Light (ALSF-2), Semiflush Lighting Installation Details (Sheet 1 of 2).
D-6238-15	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2), PAR-56 Lampholder Flasher, and Maintenance Stand Installation Details
D-6238-17	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2), Regulator Substation Floor Plan
D-6238-18	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2), Regulator Substation/Reference Lamps and Mechanical Equipment Layout
D-6238-21	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2), Regulator Substation Conduits Routing Plan

D-6238-22	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2), Substation Schematic Diagram
D-6238-23	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2), ATCT Control and Regulator Substation Schematic Diagram
D-6238-24	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage input Cabinet Assembly
D-6238-25	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Input Cabinet Assembly
D-6238-26	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Input Cabinet Assembly
D-6238-27	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Input Cabinet Details
D-6238-28	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Output Cabinet Assembly
D-6238-29	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Input Cabinet Assembly
D-6131-30	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Output Cabinet Assembly
D-6131-31	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Output Cabinet Assembly
D-6131-32	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Output Cabinet Assembly
D-6131-33	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator

	Substation, High Voltage Input/Output Cabinet Assembly
D-6131-34	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Output Cabinet Details
D-6131-35	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Output Cabinet Details
D-6131-36	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Output Cabinet Details
D-6131-37	High Intensity Approach Lighting System with Sequenced Flashing Lights (ALSF-2) Regulator Substation, High Voltage Output Cabinet Details

2.1.3 FAA standards

FAA-STD-013	Quality Control Program Requirements
FAA-STD-021	Configuration Management (Contractor Requirements)
FAA-STD-024	Preparation of Test and Evaluation Documentation

2.2 Federal publications.- The following federal publications, of the issues in effect on the date of the invitation-for-bids or request-for-proposals, form a part of this specification and are applicable to the extent specified herein.

2.2.1 Military standards

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-276	Impregnation of Porous, Nonferrous Metal castings
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility, Requirement for the Control of electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of

MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-810	Environmental Test Methods

2.2.2. <u>Military publications</u>

MIL-HDBK-217	Reliability Stress and Failure Rate Data for Electronic Equipment
MIL-HDBK-472	Maintainability Predictions
RADC-TR-75-22	Nonelectronic Reliability Notebook

2.2.3 <u>Military specifications</u>

MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys

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MIL-C-7989	Covers, light Transmitting, for Aeronautical Lights, General Specification for
MIL-C-13924	Coating, Oxide, Black, for Ferrous Metals
MIL-C-22896	Contactors
MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirement for
MIL-C-26482	Connectors, Electronic, Circular, Miniature, Quick Disconnect
MIL-E-917	Electric Power Equipment, Basic Requirements
MIL-E-17555	Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts); Packing of
MIL-I-46058	Insulating Compounds, Electrical (for coating printed circuit assemblies)
MIL-M-38510	Microcircuits, General Specifications for
MIL-S-83731	Switch, Toggle, Unsealed and Sealed Toggle, General Specification for

2.2.4 Federal specifications

QQ-A-200/9	Aluminum Alloy Bar, Rod, Shapes, Tube and Wire Extruded, 6063
QQ-A-225	Aluminum and Aluminum Alloy Bar, Rod, Wire, or Special Shapes; Rolled, Drawn, or Cold Finished, General
QQ-A-250	Aluminum and Aluminum Alloy Plate and Sheet, General Specification for
QQ-A-591	Aluminum Alloy Die Castings
QQ-A-601	Aluminum Alloy Sand Castings
QQ-P-416	Plating, Cadmium (Electrodeposited)
QQ-Z-325	Zinc Coating, Electrodeposited, Requirements for

2.3. Other publications.- The following publications, of the issues in effect on the date of the invitation-for-bids or request-for-proposals form a part of the specification.

2.3.1 National Fire Protection Association document

NFPA No. 70	National Electrical Code

2.3.2 Occupational Safety and Health Act (OSHA)

National Standards Established by Occupational Safety and Health Act (OSHA)

2.3.3 National Electrical Manufacturers Association

NEMA 3	Dusttight, Raintight, and Sleet Resistant (Ice Resistant)-Outdoor Enclosure
NEMA 12	Industrial, Dust-Tight, Drop-Proof Enclosure
NEMA FA1-3.01	Vibration Testing

2.3.4 American National Standards Institute

ANSI C37.90	IEEE Guide for Surge Withstand Capability (SWC) Tests
ANSI C39.1	American National Standard for Electrical Analog Indicating Instruments
ANSI C62.1	Quantities and Units Used in Electricity

2.3.5 American Iron and Steel Institute standard

AISI	Stain and Heat Resistant Steel, No. 13

(Copies of this specification and other applicable FAA documents may be obtained from the Contracting Officer in the office issuing the invitation-for-bids or request-for-proposals. The requests should fully identify material desired; i.e., standard, drawing, specification, and amendment numbers and dates. Request should cite the invitation-for-bids, request-for-proposal, or contract involved or other use to be made of the requested material.)

(Requests for copies of military specifications and standards should be addressed to Naval Publications and Forms Center, Attention: NPFC-105, Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.)

(Information on obtaining copies of federal specifications and standards may be obtained from General Services Administration offices in Washington, DC.; Atlanta; Auburn, Washington; Boston; Chicago; Denver; Kansas City; New York; San Francisco; and Seattle.)

(Information on obtaining NFPA documents may be obtained from the National Fire Protection Association, Battery March Park, Quincy, Massachusetts 02269.)

(Information on obtaining OSHA standards may be obtained from Department of Labor, Occupational Safety and Health, Constitution Avenue & 14th Street, NW., Washington, DC.)

(Information on obtaining NEMA publications may be provided by the National Electrical Manufacturer's Association, 2101 L Street, NW., Washington, DC 20037.)

(Information on obtaining ANSI standards will be provided by the American National Standards Institute, 70 East 45th Street, New York, New York.)

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(Copies of the AISI standards can be obtained from the American Iron and Steel Institute, 1000 16th Street, NW., Washington, DC 20036)

3. REQUIREMENTS

3.1 General.- The equipment furnished under this specification shall provide approach lighting for use on selected runways. The Approach Lighting System (ALS) shall be switchable from the High Intensity Approach Lighting System with Sequenced Flashing Lights, Category II (ALSF-2) mode, to the Simplified Short Approach Lighting System with Runway Alignment Indicator Lights (SSALR) mode. The patterns produced by these two lighting modes are shown in plan view by figures 1 and 2 respectively. The system shall be capable of providing the 3,000-foot (914 m) patterns as shown where glide slope angle restrictions require it, and also the shorter 2,400-foot (732 m) patterns for use on other domestic Category II Runways (without the last six stations). The steady burning approach lights will be connected in three constant current lighting loops as shown on FAA Drawing D-6238-4. Switching Between the modes (ALSF-2/SSALR) will be locally controlled from the substation and remotely controlled from the air traffic control tower (ATCT) via the control subsystem, which will activate the mode change relays in the substation high voltage output cabinet (refer to FAA Drawings D-6238-22 and D-6238-23). The action of this relay will reconfigure the ALS field wiring as shown in the simplified schematic figure 3. Operational modes of the flashing lights will be switched by selectively activating the appropriate trigger signals upon command from the ATCT. The approach lighting system will utilize low impact resistance structures, will employ constant current lighting techniques, and will have remotely indicated fault sensing equipment. The substation equipments (regulators, high voltage cabinets, and control and monitor subsystems) will be installed in an environmentally controlled shelter that is generally located within the runway approach zone. This shelter is not a part of this specification; however, it will provide protection for some of the equipment. The shelter equipment arrangement and detailed mounting provisions are as shown on FAA Drawings D-6238-17 and D-6238-21. The system equipment and interconnection shall comply with the National Electrical Code (NEC) and Occupational Safety and Health Act (OSHA). The required system shall be as shown in the functional block diagram, figure 4. For each circuit card assembly that requires replacement over the course of useful system life, the contractor shall provide one site spare. This specification also covers reliability and maintainability design and prediction requirements imposed on the contractor. The design shall include a requirement for a remote maintenance monitoring system capability. For each circuit card assembly that requires replacement over the course of useful system life, the contractor shall provide one site spare.

3.1.1. Equipment to be supplied by the contractor.- The ALSF-2/SSALR systems shall be complete in accordance with all specification requirements and shall include the items listed

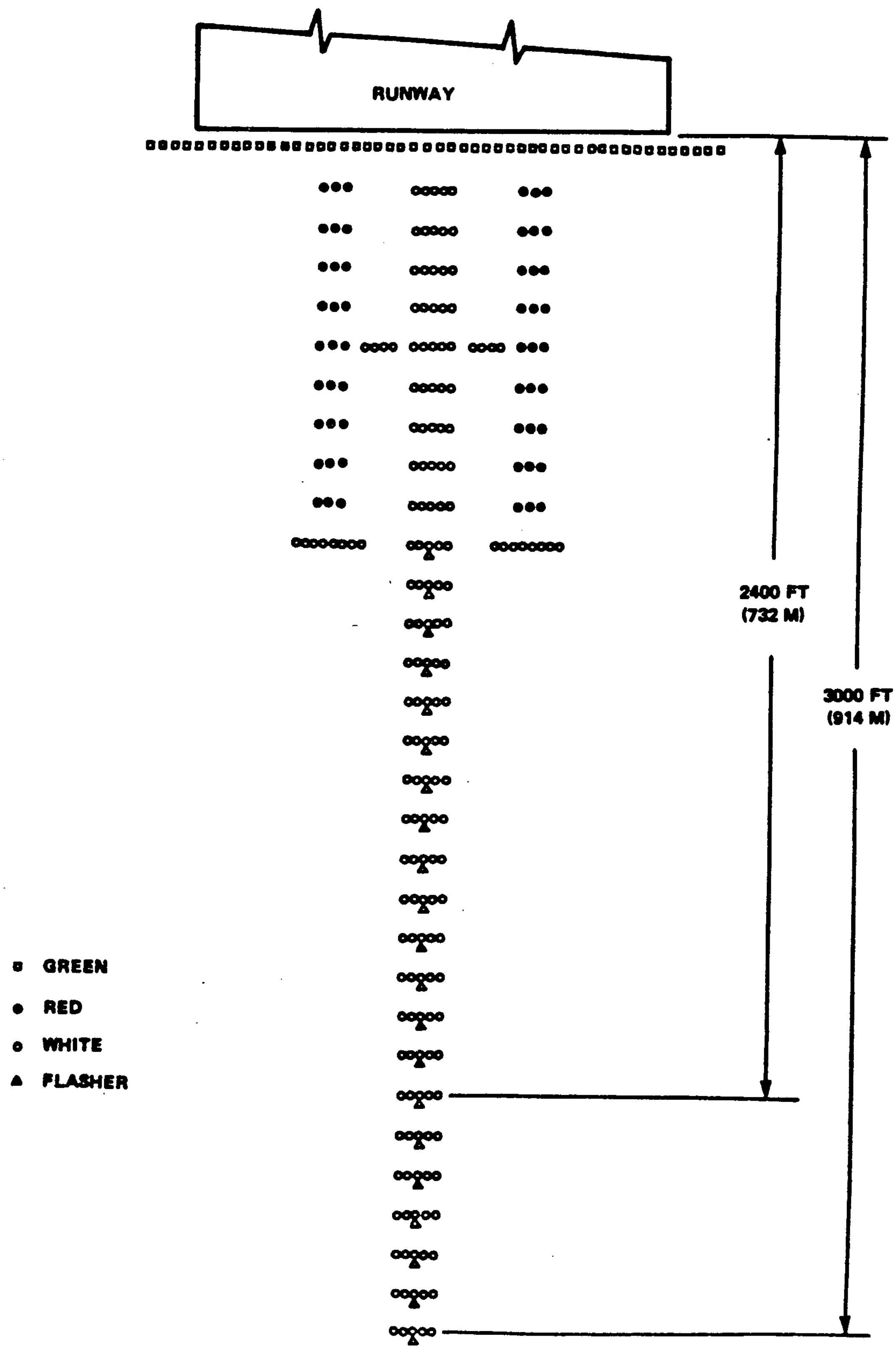

Figure 1. ALSF-2 Lighting Pattern

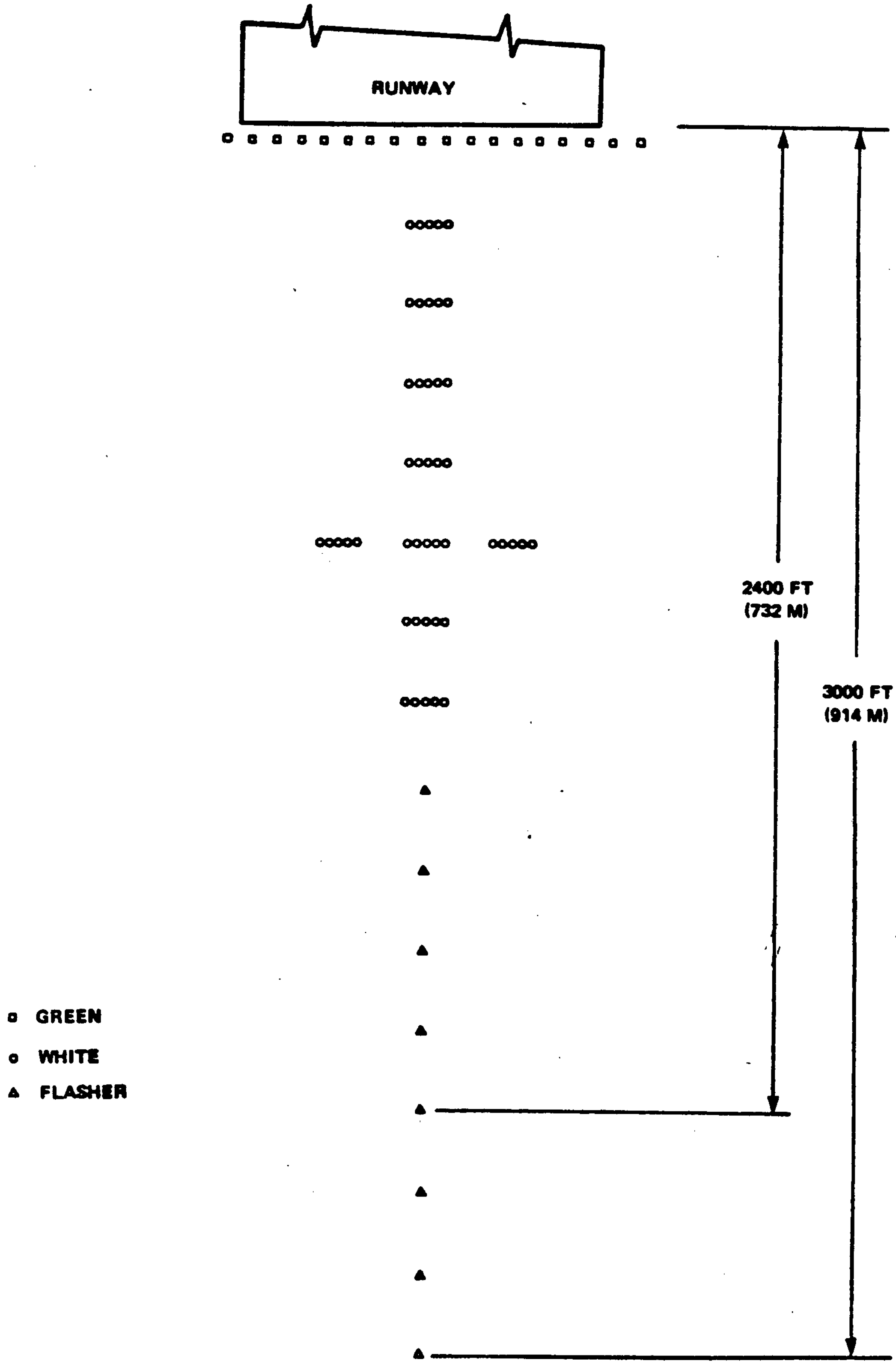

Figure 2. SSALR Lighting Pattern

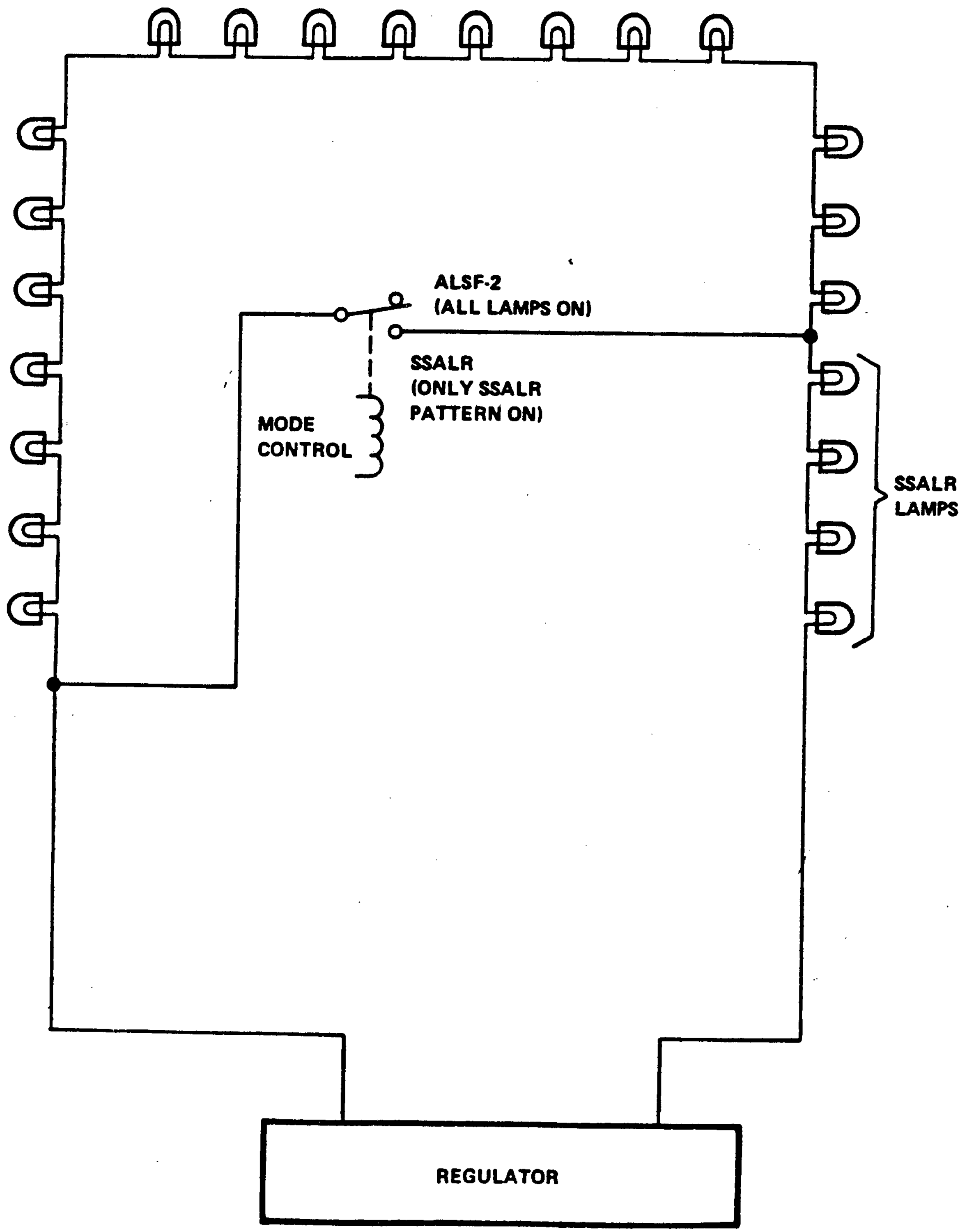

Figure 3. Mode Switching, Simplified Schematic

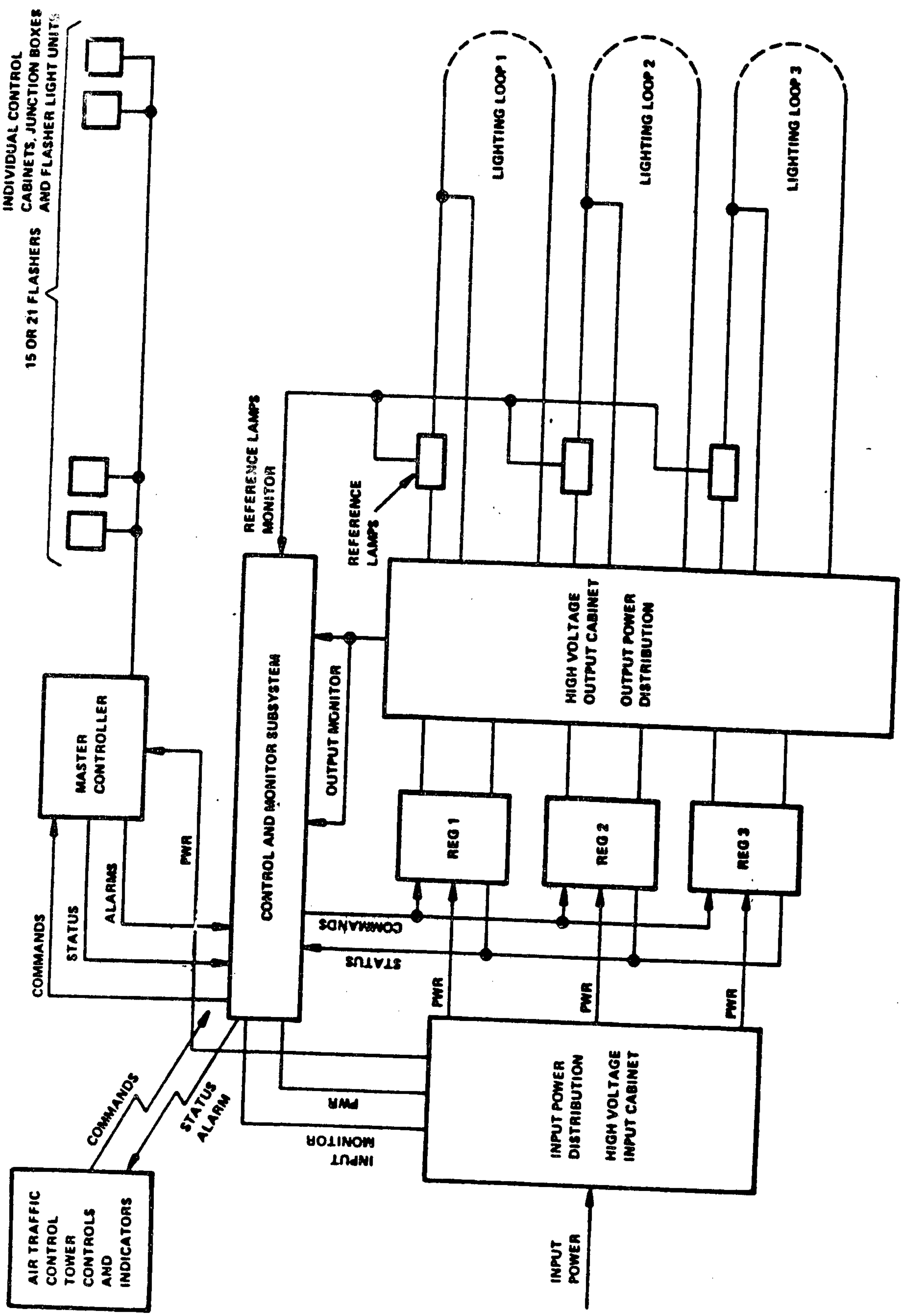

Figure 4. Functional Block Diagram

below. Quantities shall be as specified in the contract schedule.

(a) High voltage input cabinet (3.2.1)

(b) High voltage output cabinet (3.2.2)

(c) Constant current regulators (3.2.3)

(d) Control and monitor subsystem (3.2.4)

(e) Flasher master controller (3.2.5.1)

(f) Elevated flasher assemblies (Type I) (.3.2.5.3)

(g) Aiming device (3.2.5.3.1.9)

(h) Semiflush flasher assemblies (Type II) (3.2.5.4)

(i) Flasher tester (3.2.5.5)

(j) Elevated PAR-56 lampholders (3.2.6)

(k) Site spare parts (3.2.7)

(m) Junction boxes (3.3.10)

(n) Instruction books (3.7.1)

3.1.2 Other equipment.- Other equipments required to make a complete approach lighting system are listed below. These items are not furnished or required under the specification, but are briefly described herein with detailed requirements being contained in the paragraphs or in the individual equipment specifications referenced below:

(a) Isolation transformers (3.2.8.1)

(1) 300 watt, 20 ampere (A) primary, 20 A secondary (AC 150/5345-47)

(2) 500 watt, 20 A primary, 20 A secondary (AC 150/5345-47)

(3) 1500 watt, 20 A primary, 20 A secondary (FAA-E-2690)

(b) PAR-56 lamps (FAA-E-2408) (3.2.8.2)

(1) 300 watt

(2) 500 watt

(c) Flasher subsystem transformer (3.2.8.3)

(d) Utility transformer (3.2.8.4)

(e) Low impact resistant structures (3.2.8.5)

(f) Substation shelter (3.2.8.6)

(g) Semiflush fixtures (FAA-E-2491)

3.2 Performance characteristics.- The units of the system shall have the performance characteristics shown in the following paragraphs.

3.2.1 High voltage input cabinet.- A high voltage input cabinet shall be supplied for each system and shall:

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(a) Receive 2,400/4,160 volts alternating current (V ac), 3-phase, 4-wire, 60 hertz (Hz), 150 KW primary input power to the substation shelter.

(b) Provide service entrance to the substation in accordance with National Electrical Code (NEC) and OSHA requirements.

(c) Provide lightning protection for the primary input power and the input power monitoring circuits.

(d) Provide oil-filled circuit breakers for primary power distribution to the regulators, the flasher system, and the substation utility distribution system.

(e) Contain 20:1 potential and 25:5 current transformers, as required to monitor the input voltage and power consumption at the control and monitor system.

(f) Provide high voltage warning and safety provisions.

The high voltage input cabinet shall provide 2,400 V ac, 1-phase, 2-wire power to each of the regulators in the substation and shall accommodate main power switching, fusing, metering takeoff, and system input lightning protection. Circuitry and layout for the cabinet shall be in accordance with FAA Drawings D-6238-22 through D-6238-29.

3.2.1.1 Lightning protection.- Lightning arresters shall be installed between each phase of the input to ground to protect primary apparatus and wiring from lightning (see 3.6.6).

3.2.1.2 Standoff insulators.- All high voltage cable terminations and tie points shall be made on high voltage standoff insulators (Lapp 42423, or equal).

3.2.1.3 Oil-filled cutouts.- Three-phase oil-filled cutouts shall be provided to interrupt all phases of the primary power to the substation. Cutouts (General Electric 9F32FAA103, or equal) shall be of the fused type with replaceable 75 ampere fuse elements (general Electric 9F57CAA075, or equal). The three phase cutouts shall be mechanically ganged so that all three cutouts are simultaneously disconnected with one lever motion. Additionally, oil filled cutouts (General Electric 9F32FAA103, or equal) shall be used in the primary supply to the flasher transformer and the utility/control transformer, and shall be fused with replaceable fuse elements (General Electric 9F57CAA020, or equal) rated at 20 amperes.

3.2.1.4 Instrument potential transformers.- Potential transformers (General Electric 653X85-JVM3, or equal) having a ratio of 20:1 shall be provided to supply the required voltage monitoring signals to the input voltmeter and wattmeter located in the substation control and monitoring assembly. The transformers shall be equipped with fused primary windings to isolate high voltages in the event of transformer failure.

3.2.1.5 Instrument current transformers.- Current transformers (General Electric 497X24-JKM3, or equal) having a ratio of 25 to 5 amperes shall be provided to supply current reference to the input power, 2-1/2 element, 3 phase wattmeter located in the substation control and monitor assembly. The current transformers shall be protected by primary bypass thyrite (General Electric 5207649G1, or equal) and secondary thyrite protectors (General Electric 9238208G1, or equal).

3.2.1.6 Service entrance.- The service entrance shall be through precut holes in the bottom of the cabinet as shown on FAA-Drawing D-6238-24.

3.2.2 High voltage output cabinet.- A high voltage output cabinet shall be supplied for each system and shall:

(a) Receive constant current regulated power from the regulators for each of the three lighting loops.

(b) Provide service exit from the substation in accordance with NEC and OSHA requirements.

(c) Provide lightning protection for the output circuits and for the output monitoring circuits.

(d) Contain shorting disconnects for isolation of the light field during servicing and maintenance.

(e) Perform the high voltage output switching function required to change operational modes.

(f) Contain 20:1 potential transformers as required to monitor output voltage level.

(g) Provide high voltage warning and safety provisions.

The high voltage output cabinet shall provide for distribution and switching of the current from three 50 KW constant current regulators to three output lighting loops in the ALS light field. The output cabinet shall be equipped with instrument potential transformers shorting disconnects, ALSF-2/SSALR switching relays, and lightning protection circuitry. Layout for the cabinet shall be in accordance with FAA Drawings D-6238-22 and D-6238-23 and D-6131-30 through D-6131-37.

3.2.2.1 Lightning protection.- The output power lines from the cabinet shall be protected from lightning by installation of lightning arresters ar each standoff feeding the light field circuits (see 3.6.6).

3.2.2.2 Standoff insulators.- All high voltage cable terminations and tie points shall be made on standoff insulators identical to the type specified in 3.2.1.2.

3.2.2.3 Shorting disconnect.- Shorting disconnects (Crouse-Hinds 30196, or equal) shall be connected in each output constant current loop. These plug cutouts shall isolate the load from the regulator and short both the regulator lines and the light field lines to provide safety to maintenance personnel and to preclude open circuit regulator outputs. The cable connecting lugs shall have pressure plates under the compression screws.

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3.2.2.4 Instrument potential transformers.- Potential transformers (GE 643X87, or equal) shall be installed to allow monitoring of output loop voltages. Transformers shall have both legs of the primary circuits fused. The output of potential transformers shall be wired to the output terminal board as shown on FAA Drawings D-6238-22 and D-6238-23. The ratio of these transformers shall be 20:1. They shall provide inputs to both the light field monitoring circuits and the output voltage meter located in the substation control and monitor assembly.

3.2.2.5 ALSF-2/SSALR mode change relays.- High performance vacuum relays (Kilovac KC-2, or equal) shall be installed to select ALSF-2 or SSALR light field configuration as shown on FAA Drawings D-6238-22, D-6238-23, and D-6131-31.

3.2.2.6 Service exit.- Service exit shall be made through precut holes in the bottom of the cabinet as shown on FAA Drawing D-6131-32.

3.2.3 Constant current regulator.- Three 50 KW constant current regulators shall be supplied for each system, one for each steady burning lighting loop as shown on FAA Drawing D-6238-4. The regulators shall all be commanded simultaneously by the control subsystem and each shall:

(a) Operate from a 2,400 V ac, single phase, 2-wire 60 Hz source.

(b) Provide output current monitoring meter.

(c) Have 24 V dc logic levels (see 1.3.15) for control and status signals.

(d) Provide regulated constant current to series lighting loops that is variable in 5 discrete steps as a function of selected brightness.

Provisions shall be made for stepped-brightness selection without interrupting load current. The assemble shall have an isolation transformer, a current detecting system, transient suppressors, brightness selection control circuitry, open-circuit and over current protection, and an output current meter. Solid-state electronic circuitry and fixed winding transformers or reactors shall be used to accomplish regulation at the various brightness steps. (No moving coil or other mechanical apparatus shall be used for regulation.) Relays may be used for on/off control of the high voltage input but all control and monitoring interfaces shall be solid-state and shall have 24 V dc logic levels as defined in 1.3.15.

3.2.3.1 Input power.- The regulator shall operate without degraded performance with input voltages ranging from 2,280 to 2,640 C ac, 60 Hz single phase.

3.2.3.2 Output regulation.- The regulator shall automatically maintain its normal output current within the limits set forth in table I for all input voltages as specified in 3.2.3.1 and for all variations in output load from short circuit to full load (50 KW). The assembly shall meet these same requirements with 10 percent of the total load (5 KW) consisting of suitably loaded isolating transformers which are then open-circuited at their secondaries.

<u>3.2.3.3. Efficiency</u>.- The efficiency of the regulator shall be greater than 93 percent at maximum brightness with an input voltage of 2,400 V ac, unity power factor load, and at an ambient temperature of 77 degrees F (25 degrees C). The efficiency shall be measured at rated load.

<u>3.2.3.4 Power factor</u>.- The regulator power factor shall be equal to or greater than 0.95 at rated load (50 KW) in step 5 with a resistive load. The power factor shall always be lagging and shall not be less than 0.5 for any intensity step in the ALSF-2 mode or the SSALR mode, in which the power consumed by the load is equal to or greater than 10 percent of the full rated regulator capacity. Power factor correction, if needed, shall be internal to the regulator, and shall be switched as required to maintain a lagging power factor equal to or greater than 0.5 and less than 1 in step 5 for a resistive load of 5 KW to 50 KW.

<u>3.2.3.5 Temperature rise</u>.- The temperature rise for primary and secondary windings, as determined by the resistance method, shall not exceed 149 degrees F (65 degrees C) when operated at full load and unity power factor. Oil temperature, within 3 inches (76 mm) of the top and 3 inches (76 mm) of any side wall of the tank, shall not exceed 131 degrees F (55 degrees C rise when operated in an ambient environment of 77 degrees F (25 degrees C). Dry type regulators shall have Type H insulation temperature characteristics in accordance with MIL-E-917.

<u>3.2.3.6 Output isolation</u>.- The regulator output shall be electrically isolated from the input and shall also be floating (not grounded).

<u>3.2.3.7 Open-circuit protection</u>.- An open-circuit protection feature shall be provided such that the regulator will be automatically switched off within 2 seconds after the output circuit is opened. Upon removal of the open circuit, the regulator shall not automatically restart. In order to restart the regulator, the regulator on/off control circuit (either local or remote) shall be cycled through the off position and returned to the on position to reset the open-circuit protection feature.

Table I. Regulator Output Requirements

Brightness Step	Output Current (Amperes)	Output Tolerance (Amperes)
5	20	+ 0.0, -0.4
4	15.8	+ 0.4
3	12.4	+ 0.3
2	10.3	+ 0.3
1	8.5	+ 0.2

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3.2.3.8 Open-circuit voltage.- In the event of failure of the open-circuit protection feature, or in the interim between where the open circuit occurs and the protection circuit operates, the peak open circuit voltage shall not exceed 4,500 volts, including transients or switching spikes.

3.2.3.9 Overcurrent protection.- An automatic overcurrent protection feature shall be provided such that the regulator will be automatically switched off if the output current exceeds 105 percent of its rated output (21 amperes). The feature shall have a time delay to prevent its activation on transients and other spurious signals such that activation shall occur between 0.5 and 2 seconds after overcurrent. Reset of this feature shall require intervention by maintenance personnel.

3.2.3.10 Output monitor.- An ac ammeter shall be provided on the front of the regulator to indicate the output current. This meter shall be at least 3.5 inches (89 mm) in diameter and shall have an accuracy of better than 1 percent without calibration cards or correction curves. The instrument shall be isolated from the output circuit by an instrument current transformer to remove the high voltage safety hazard. Full scale for the ammeter shall be 25 amperes.

3.2.3.11 Oil tank.- The oil tank containing the magnetic components of the regulator shall be welded steel construction and shall have a gasketed removable cover to allow access for servicing. The input/output and control wiring entrance points shall be conspicuously labeled with their functional names (Input, Output, Hi, Lo, etc.). An oil drain plug and an oil sampling valve shall be provided on the side of the tank not more than 2 inches (51 mm) above the bottom. An oil level gage shall be provided that is readable from outside the tank. For all connections leaving the tank, a means shall be provided to prevent oil siphoning. A clamp-type terminal lug shall be provided on the outside of the regulator tank for connection to ground that will accommodate wire sizes from 2 to 6 American Wire Gage (AWG).

3.2.3.12 Control.- Control of the regulator shall be possible from a front panel switch on the regulator and from the control subsystem. The local control switch shall be a 7 position rotary switch which has the following positions as it is rotated in the clockwise direction. REMOTE - OFF - B1 - B2- B3 - B4 - B5. In OFF the regulator shall be disconnected from the primary power source. In B1 through B5 the regulator shall connect to the primary and provide regulated output current for the brightness selected. In the REMOTE position all local commands shall be inactive and the unit shall be under the control of the control subsystem. Remote commands, when selected, shall be 24 V dc high logic. A terminal board that is conspicuously marked "CONTROL" shall have terminals labeled: COMMON, ON, B1, B2, B3, B4, and B5 for these respective functions. High voltage components shall be isolated from low voltage components by means of separate compartments. Components installed on the door shall not protrude into the high voltage compartment. All ungrounded metal shall be protected from personnel contact by insulated or grounded barriers.

3.2.3.13 Status.- Status monitoring signals (24 V dc high logic) shall be generated by the regulator control electronic circuitry that is indicative of the actual status of the regulator and that the command received (whether local or remote) has been, in fact, activated. These signals shall be available on a terminal board that is conspicuously marked "STATUS" and shall be labeled COMMON, ON, B1, B2, B3, B4, B5, and REMOTE (RMT).

3.2.3.14 Output current surge limitation.- Design of the regulator shall be such that switching the regulator on and off, changing brightness steps, or shorting the load shall not cause an output surge with (1) true rms amplitude greater than the next brightness step being switched; and (2) a time duration of longer than three 60 Hz cycles. Also, no surge shall cause the series connected incandesant lamps to flash or be damaged in any way. If power is continuously provided to the circuitry when the rotary switch is in the off position for surge limitation purposes, then a separate front panel switch labeled "internal control power" shall be provided to disconnect power from the printed circuit boards. Time delay, if incorporated, when switching the regulator on and off, shall not cause an interval of more than 2 seconds to elapse before the unit operates to deliver the current selected. Pulsation or hunting of output current shall be limited to 2 seconds or less under all conditions of switching.

3.2.4 Control and monitor subsystem.- A control and monitor subsystem shall be supplied with each system and shall consist of three major units.

(a) The substation control and monitor assembly

(b) The remote electronic chassis

(c) The remote control panel

3.2.4.1 Substation control and monitor assembly.- The substation control and monitor assembly shall:

(a) Operate from 120 V ac, 60 Hz power.

(b) Provide monitoring meters for input voltage, output voltage, and input power.

(c) Contain dc power supplies as required for the operation of the control and monitor electronic circuits and local panel indicator lamps.

(d) Provide lightning protection for the input power and the data transmissions link to the remote electronic chassis.

(e) Contain the substation control panel (see figure 5) for controlling the operation of the system including:

(1) Power on

(2) Power off

(3) Approach lights on

(4) Approach lights off

(5) Flashing lights on

(6) Flashing lights off

(7) Mode ALSF

(8) Mode SSALR

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(e) Have switches that are electrically isolated from their indicators, such that, the indication is a feedback from the controlled equipment which denotes that the requested action has, in fact, taken place. (Except meter selectors). Electronic lamp driver circuitry shall be provided in the remote electronic chassis.

(f) Have alternate action switching or mechanical interlocked hold features such that the command will not be lost, or require resetting, in the event of power loss. (Brightness 5 is excepted.) Solenoid hold circuitry shall not be used.

3.2.4.4.1.1 Color.- All indicators shall illuminate in amber when activated except:

(a) ON indicators shall illuminate in green (OFF is amber).

(b) SSALR indicator shall illuminate in green (ALSF is amber).

(c) FAILURE indicator shall illuminate in red.

(d) SUBSTATION indicator shall illuminate in red.

(e) LOCAL indicator shall illuminate in red.

(f) REMOTE indicator shall illuminate in green.

3.2.4.4.1.2 Dimming.- A rotary control shall be provided on the remote control panel to adjust the intensity of the panel indicators from full voltage to 50 percent of full voltage. Maximum brightness shall occur when the control is in the clockwise position. Dimming is not required at the substation control panel.

3.2.4.4.1.3 Lamp test.- A lamp test feature shall be provided. Depressing the lamp test switch shall cause all lamps to illuminate and shall also cause the alarm buzzer to sound. This shall be separate switch on the substation panel and shall utilize the runway identification (ID) switch in the remote panel.

3.2.4.4.1.4 Runway identification.- The runway identification switch/indicator (Legend 3R on figure 6) shall be provided with a blank lens. This module also serves as the lamp test pushbutton in the remote panel.

3.2.4.4.2 Control algorithms.- Electronic circuitry shall be provided as required to convert the requested commands (switch closures) into actual control signals for the various controlled equipments. Control algorithms shall primarily be solved in the substation control unit; however, circuitry shall be provided in the remote chassis as required to implement remote functions. Refer to figures 7 and 8 for block diagrams.

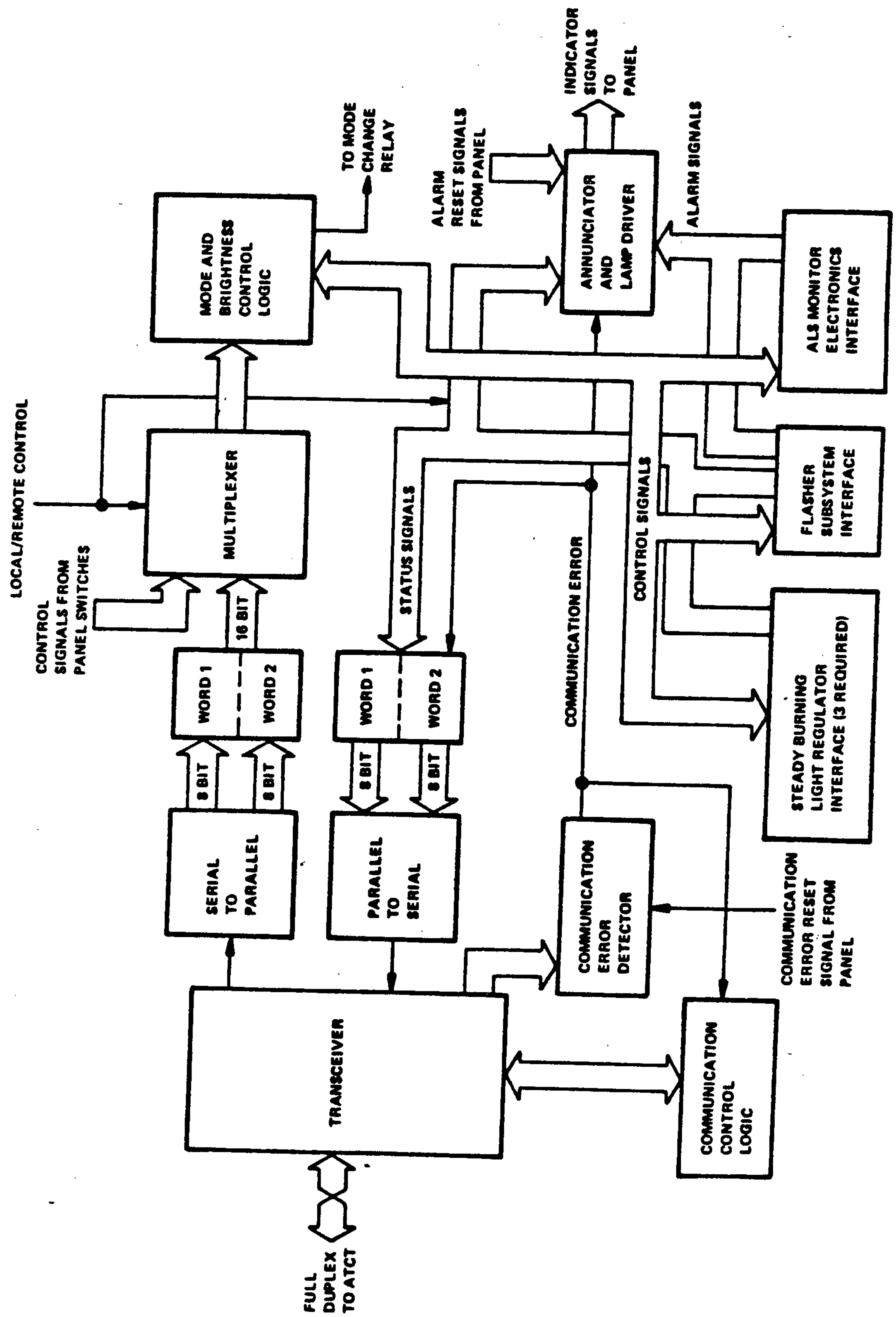

Figure 7. Substation Control Electronics Block Diagram

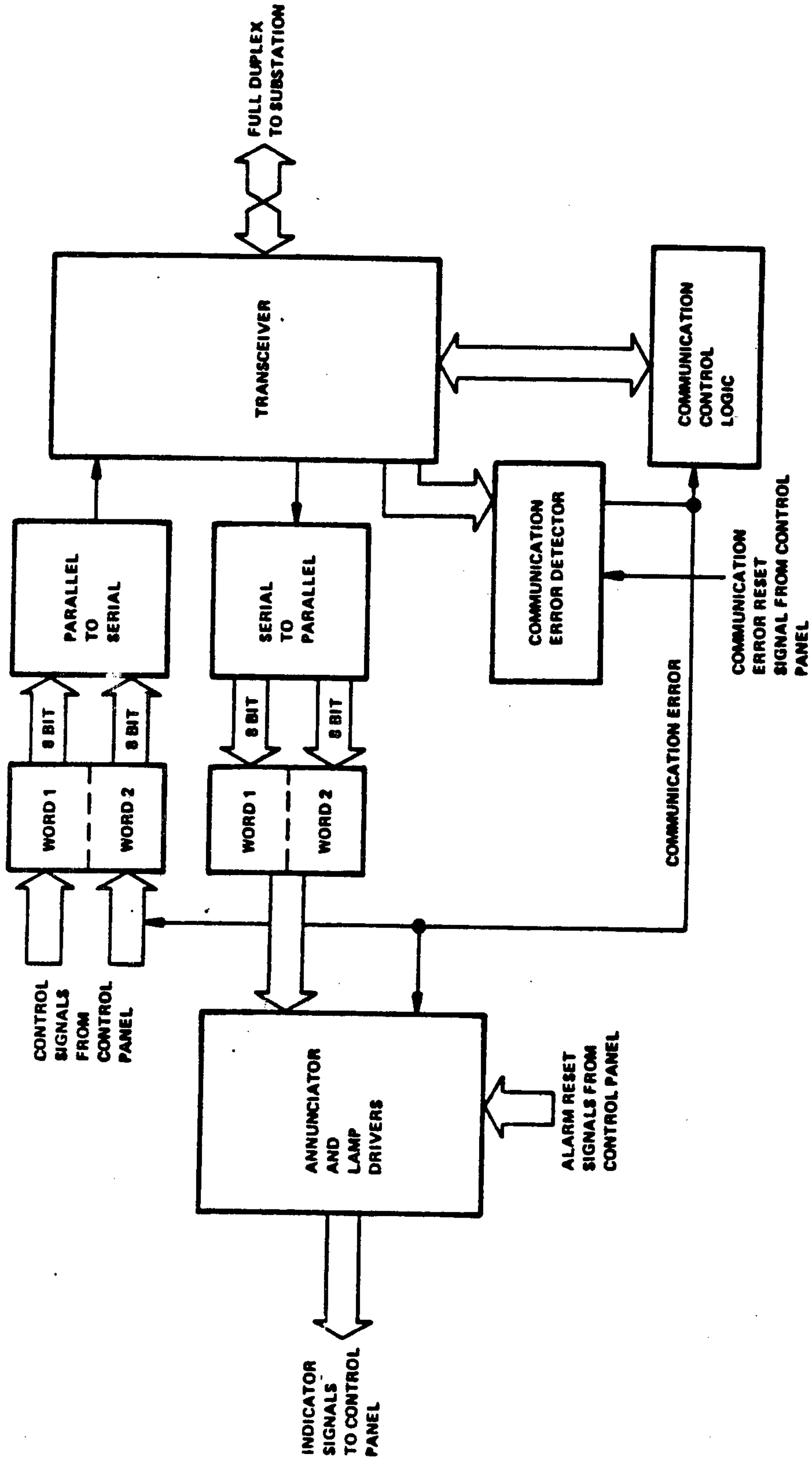

Figure 8. Remote Electronic Chassis Block Diagram

3.2.4.4.2.1. Local/remote control.- Data upon which the system operates shall originate from either the remote control panel via data link or from the substation control panel. When the position of the substation LOCAL/REMOTE switch is in the LOCAL position, data shall originate from the substation panel and the ATCT SUBSTATION indicator shall be illuminated. When in the REMOTE position, the data shall originate from the remote panel. If any of the control equipment (regulators or flashers) is placed in a local control mode via its own independent LOCAL/REMOTE switch when the substation is in the REMOTE mode, the ATCT SUBSTATION indicator shall be illuminated and the substation REMOTE indicator shall blink.

3.2.4.4.2.2 Brightness control.- Logic shall be provided to cause the selected brightness to be activated by the regulators, monitor, and flasher equipment. The flasher shall be commanded to LOW intensity for brightness steps 1 or 2, to MEDIUM for step 3, and to HIGH for steps 4 or 5. The brightness control switches shall be mechanically interlocked. Depression of any switch shall release any other switch; and switch 5 shall not latch in the depressed state, but shall release all others when it is depressed.

3.2.4.4.2.3 Brightness 5 control logic.- Logic shall be provided to prevent brightness 5 from remaining active for more than 15 minutes ±10 seconds without reinitiating the command. Brightness 5 is a momentary signal and must be electronically latched. Once latched, the Brightness 5 control shall be active for only 15 minutes, unless reinitiated during the 15 minute period. At 14.5 minutes ±10 seconds, an alert signal shall be generated and sent to the control panel to "beep" the alarm and cause the B5 indicator lamp to blink. At he end of 15 minutes, the B5 control latch shall be reset and B4 logic activated, causing the lighting system to switch into brightness 4. Until any brightness level is selected, the system shall remain in brightness 4 and the alert signal shall remain active, causing the B4 indicator to blink, indicating that the actual brightness is not as selected by the operator. When an electrical power failure interruption occurs as a result of a power source transfer, the logic shall retain B5 when no other intensity is selected.

3.2.4.4.2.4 Regulator operation.- The logical control algorithm for the regulator on/off and brightness control functions shall be such that, when a regulator is turned on, it is turned on with B1 selected and after a 3.5 second time delay, the desired brightness is selected. The delay allows the steady burning lamps to come up to operating temperature before large energy output conditions are imposed on the system. After initial warm up, it shall be possible to select any brightness without additional delays. The 3.5 second time delay shall not be used when the regulator is turned off by input power interruption and then to on when input power returns, such as occurs when power is transferred from engine generator to commercial power using the E/G transfer switch.

3.2.4.4.2.5 Flashing light operation.- Logic shall be provided to turn the flashing lights on/off, change modes, or change brightness upon command. No special timing considerations are required.

3.2.4.4.2.6 Mode change logic.- Logic shall be provided to inhibit the changing of system mode (ALSF/SSALR) when any of the three regulators is in the ON condition. Mode changing shall be inhibited even if regulator power is turned on at the regulator local control switch. In addition, when a mode change is commanded from the control panel either locally or remotely, the logic automatically shall turn the regulator power off, change the mode, and sequence the power back up to the selected brightness.

3.2.4.4.2.7 Alarm.- An audible electronic signal shall be provided and shall output a steady tone of 2000 Hz $\pm$500 Hz with a sound level output of 55 to 70 decibels (dB). The alarm operate as follows:

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(a) When a failure condition is received from either the strobe light (flasher) control system or the ALS monitor subsystem, it shall initiate a steady tone until the FAILURE pushbutton is depressed. The continuous tone shall stop after the switch is depressed until a new failure condition occurs.

(b) When a communication fault occurs, the alarm shall initiate a beeping mode where the tone is emitted for 0.33 second and is off for 0.66 second. The beeping shall continue until the COMM FAULT pushbutton is depressed. It shall not reenter the continuous beep mode until after the fault condition is cleared and new fault is detected.

(c) When caution signal is received from either the flashing lighting system or the ALS monitor subsystem, the alarm shall emit a single 0.2 second tone. It shall emit this tone each time a caution condition occurs.

(d) Whenever a mode error is detected, a single 0.1 second tone shall be generated and the ALSF/SSALR status indicator shall be blinked until the steady burning and flashing lights have both switched to the mode selected. Detection of this error shall be inhibited for 1 second after a mode change is requested.

(e) Whenever the brightness 5 timer passes either the 14.5 minute warning, or switches to B4 at 15 minutes, a single 0.1 second tone shall be generated.

(f) The previously described modes shall operate independently. For example, if a communication fault and a failure condition existed simultaneously, the alarm would emit a continuous tone. If the FAILURE pushbutton was depressed, the alarm would start beeping until the COMM FAULT pushbutton is depressed. If a caution signal were to occur, the alarm would beep once. The substation alarm shall not be active when the system is in remote mode nor shall the tower alarm be active when the system is in local mode.

<u>3.2.4.4.2.8 Blinking</u>.- An oscillator signal shall be provided for the blinking of indicator lights or the beeping of alarms. This signal shall have an on-time of 0.33 second and an off-time of 0.66 second.

<u>3.2.4.4.2.9 Transients</u>.- All switching transients shall be suppressed using low pass filtering techniques as required. Switching at any point in the system shall not cause undesired action at any other point.

<u>3.2.4.4.3 Data transmission</u>.- The remote electronic chassis and the substation control and monitor assembly shall be connected together via a 2 wire, half duplex, phase coherent, frequency

shift keyed (fsk) data link. The transmission shall be asynchronous, serial binary, shall have the characteristics required in table II, and shall detect communications errors as required by 3.2.4.4.3.3. The transmission link is required to operate with at least an 8 dB signal-to-noise ratio over a distance of 2 miles (3.2 km) or more without intermediate boosters or line amplifiers. Loss of communications shall not cause the activation of erratic modes of operation. The two wire transmission lines shall terminate in the remote electronic chassis and the substation control and monitor assembly at input circuitry that eliminates line noise from the transmitted and received signals.

Table II. Transmission Characteristics

Rate.	10 words/sec. minimum
Frequency tolerance	0.5% max.
Output impedance.	600 ohms
Transmitter output level.	-12 dBm to 0 dBm (Adjustable)
Receiver dynamic range.	-50 dBm to 0 dBm
Bit error rate (8 db S/N)	1 x 10-5 max
Peak-to-peak jitter	5% max
Carrier detect threshold.	-50 dBm

<u>3.2.4.4.3.1 Frequencies</u>.- The ATCT to substation communication link (downlink) shall transmit 1270 Hz and 1070 Hz respectively for mark and space. The substation to tower link (up-link) shall transmit 2225 Hz and 2025 Hz for mark and space. ATCT and substation receiver frequencies shall be compatible.

<u>3.2.4.4.3.2 Data framing</u>.- Two 8-bit data words shall be transmitted, alternately. A universal asynchronous receiver/transmitter (UART) shall be utilized to frame each word. The data word shall consist of a start bit, 8 data bits, a parity bit, and 2 stop bits. The parity bit shall be implemented to provide odd parity. Data bit 1 shall be used for word identification, with "0" denoting word 1, and "1" denoting word 2. Unused data bits shall be set to zero. Data formats shall be as shown in table III.

<u>3.2.4.4.3.3 Communication fault</u>.- A communication fault (COMM FAULT) condition is defined as an up-link carrier loss, parity error, framing error, or overrun error. Upon detection of communications fault, the control logic shall hold the last valid command. Four classes of errors shall be detected by the serial data interface and are defined as follows:

(a) Carrier loss - Generated if the carrier is not received.

(b) Parity error - Generated if parity bit is erroneous.

(c) Framing error - Generated if received data does not have a valid stop bit.

(d) Overrun error - Generated if data is not transferred to the receiver holding register before next character read.

3.2.4.4.3.4 Lightning protectors.- Lightning protectors shall be provided for all communication and power conductors and shall be installed as near as possible to their point of entrance into the housing. The arresters shall be properly combined, where necessary, to meet the circuit voltage requirements (see 3.6.6).

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3.2.4.4.5.2 Input voltage metering.- The input voltage meter shall be a General Electric 50-103021PZUA2, or equal, transformer rated, 50/60 Hz, iron van type, taut-band, 150 volt rated instrument. Full scale for the voltmeter shall be 3,000 volts utilizing a 50 degree scale of 6.9 inches (175 mm) length. Voltage input to the meter is derived from the potential transformers used with the watt-meter input. Pushbutton switches shall be provided to select phase A, B, or C voltages and to turn the voltmeter off. Pushbutton switches shall be mechanically interlocked so that only one position may be selected. Voltage input to the meter is a nominal 150 volts, for full scale deflection.

3.2.4.4.5.3 Output voltage metering.- The output voltage meter shall be identical to the input meter and shall be supplied from potential transformers located within the substation high voltage output cabinet. Inputs to the meter shall be through pushbutton switches to allow selection of loop 1, 2, or 3 and to turn the meter off. Switches shall be mechanically interlocked allowing only one switch to be closed.

3.2.4.4.6 Power requirements.- The system shall contain all power supplies required for operation and shall utilized 120 V ac, 60 Hz, single phase power input, both for the remote electronic chassis and the substation control and monitor assembly.

3.2.4.4.7 Elapsed time meter.- Two elapsed time meters shall be installed behind the top front panel of the control and monitor cabinet. One meter shall indicate the number of hours of operation that the approach lights are turned on and the other meter shall indicate the number of hours of operation on the high intensity step 5 position. The meters shall indicate up to 99,999 hours and indicate total time in hours and 10ths of hours. The meter shall be a recycling type. The total time on the meter shall be retained after loss of power.

3.2.4.5 Monitor subsystem.- The monitor subsystem shall provide an indication in brightness level settings B1 and B2 whether power is being delivered to the lamps when the system is energized. In brightness level settings B3, B4, and B5, the monitor subsystem shall provide an indication of the number of failed lamps in each of the three current loops. The monitor subsystem shall consist of three identical channels, one for each ALS lighting loop. Each channel shall sense the driving voltage of one constant current loop, and compare this voltage with the voltage developed across a standard reference lamp (300 W or 500 W) that is installed int he same lamp circuit lighting loop. The result of this comparison shall be adjusted to zero (null) when all lamps are known to be good (by visual observation) and any future deviation from this null shall be interpreted by the monitor as a change in circuit impedance (failed lamps or change in cable connector resistances). Replacing one reference lamp shall not affect the setting of other loop null alignments. The input voltages (both circuit and reference) shall be filtered, scaled for the proper brightness and mode, and amplified in accordance with the detailed requirements of the specification. The monitor shall have sufficient dynamic range to sense any number of failed lamps in each loop, from 1 to 10 in the ALSF-2 mode, and from 1 to 5 in the SSALR mode. Detection accuracy shall be 1 lamp. The ALSF-2 failure detection circuitry shall be initially adjusted to detect 6 failed 300 W lamps; however, it shall be adjustable for any number from 3 to 10. The ALSF-2 caution detection circuitry shall be initially adjusted to detect 5 failed 300 W lamps; however, it shall be adjustable for any number from 2 to 9. In the SSALR mode, failure shall occur at 3 lamps (300 W) with adjustment possible from 2 to 5 and caution shall occur at 2 lamps (300 W) with adjustment range from 1 to 4. The monitor subsystem shall be capable of monitoring the system in either the ALSF-2 or the SSALR mode. The monitor shall have an adjustment for each loop and mode to compensate for loop resistance variations. The numerical values in paragraphs 3.2.4.5 through 3.2.4.5.3.3 shall be used as a guide to design the monitor.

<u>3.2.4.5.1 System interface</u>.- The following inputs and outputs shall be required for proper ALS monitor subsystem operation.

(a) Three loop voltage inputs, one input per LAS regulator, shall be required. The input current shall not exceed 5 milliamperes ac in any mode or brightness setting. Each voltage input will be obtained from the secondary of a 20 to 1 stepdown voltage transformer located in the high voltage output cabinet. The primary of the voltage transformers will be connected across the output terminals of the ALS regulators (FAA Drawing D-6238-23). The typical values of the voltage inputs to the ALS monitor are shown for the ALSF-2 and SSALR modes in table VI..

(b) Three reference voltage inputs, one input per ALS regulator, shall be required. The input current shall not exceed 2 milliamperes rms. Each reference voltage input shall be connected across an individual reference lamp (300 watt or 500 W). The reference lamps will be connected to the secondary sides of standard lamp transformers, with the primary sides connected in series with an individual current loop of ALS regulators. The reference lamps sense the current in the corresponding current loop and compensate for the lamp impedance variations. The typical values of the reference voltage are summarized in table VI. The reference voltage input to monitor the circuitry shall be protected against the high voltage that will be applied to the input when the isolation transformer has a high impedance load or no load because of lamp and shorting device failure.

(c) The ALS monitor subsystem shall be controlled by seven input control signals originating at the control subsystem. These signals provide system status information tot he monitor as required to normalize the computations as a function of brightness and mode. Each control input shall be TTL compatible. The logic levels on input control signals shall be as specified in table VII.

(d) The ALS monitor equipment shall output two alarm signals, caution alarm and failure alarm, with a common return to the ALS control subsystem. Alarm signals shall be TTL compatible. The outputs shall be logic high in the corresponding alarm condition.

3.2.4.5.2 Voltage monitoring channels.- Three identical voltage monitoring channels, one for each ALS lighting loop, and each consisting of the electronic circuits to meet functional requirements as specified herein, shall be provided for each monitor subsystem. Refer to figure 9 for a complete functional block diagram. Component selection and circuitry shall be designed for low long-term drift characteristics. Stability shall be such that periodic adjustment shall not be required more often than every 3 months. Maximum allowable unidirectional drift during this period shall be 2 lamps in the ALSF-2 mode, and 1 lamp in SSALR. The stability of the monitor shall be such that periodic adjustment shall not be required more often than every 3 months due to drift in the monitor circuit components.

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<u>3.2.4.5.2.1 Loop voltage conditioner</u>.- The loop voltage conditioner shall consist of a transient suppressor, a low-pass filter, and a voltage dividing network. Transients appearing on the input voltage shall be suppressed so that positive or negative overvoltages shall not exceed 300 volts. Gas-filled spark gaps or other slow responding transient suppressors shall not be used. A low-pass filter shall be provided to eliminate high-frequency components of the input voltage signal. The upper cutoff frequency shall be greater than 300 Hz and less than 500 Hz. The input voltage signal shall be divided such that the output voltage shall be 7 volts rms when the ALS is in either SSALR or ALSF-2 mode, and brightness 5 is selected. Provision shall be made to manually adjust the required output voltage since the input voltage will vary depending on mode, brightness setting, and the number of lamps connected to each loop. The typical values of input voltage signals are given in table VI. Provision shall be made to manually adjust the conditioned loop input voltages in the ALSF-2 and SSALR modes with a range to accommodate the voltages of table VI (plus an additional tolerance of +10 percent). External attenuation resistors shall be provided to drop the loop voltage for SSALR systems having 18 to 31 500-watt lamps. For a threshold containing 61 500-watt lamps in the ALSF-2 configuration and 30 or 31 500-watt lamps in the SSALR configuration, the loop 1 input voltage shall be decreased by means of a fixed resistor in service with the loop voltage input. The value of the resistor shall allow operation of the ALS monitor system in brightness 5 with an ALSF-2 loop input voltage of 110 ±25 V ac and an SSALR loop input voltage of 37 ±7 V ac. The resistor shall be mounted in the control and monitor cabinet, external to the ALS monitor circuit. The resistor shall be in series with the loop 1 input to the ALS monitor circuit. Provisions shall be made to either remove the resistor and replace it with a jumper wire, or short the resistor to operate loop 1 with the input voltages specified in table VI. This change in connections shall be accomplished by the use of a screwdriver.

<u>3.2.4.5.2.2 Reference voltage conditioner</u>.- The reference voltage conditioner shall consist of a transient suppressor, a low-pass filter, and a voltage divider. Transients appearing on the reference voltage input shall be suppressed so that positive or negative overvoltages shall not exceed 50 volts. Slow responding transient suppressors such as gas-filled spark gaps are prohibited. A low-pass filter shall be provided to eliminate high-frequency components of the reference voltage. The upper cutoff frequency shall be greater than 300 Hz and less than 500 Hz. The filtered reference signal shall be divided by 2. An adjustment shall be provided to normalize the conditioned voltage of either a 300-watt lamp or a 500-watt lamp that has a brightness step 5 voltage of 17 ±5 V rms and 25 ±5 V rms, respectively.

<u>3.2.4.5.2.3 Voltage normalizers</u>.- The voltage normalizer shall be comprised of a resistive divider network, a switching network, and a normalizing amplifier. Two identical voltage normalizers, one for the loop voltage and the other for the reference voltage,

shall be required for each channel. The resistive divider network shall have five taps, one tap for each brightness setting. The voltage ratio (output voltage divided by input voltage) for each brightness setting shall be as specified in table VIII. The switching network shall be solid-state, shall select only one tap at a time out of five taps of the resistive divided network, and shall connect the selected tap to the normalizing amplifier. The selection of the tap shall be made corresponding to the brightness setting. The resistance shall be less than 200 ohms between the selected tap and the normalizing amplifier but shall be greater than 200 megohms between each nonselected tap and the normalizing amplifier. The normalizing amplifier shall be an ac, low-pass, linear amplifier. The reference voltage normalizer shall have an adjustment provided for brightness steps 3 through 5. The loop voltage normalizer shall have separate adjustments provided for brightness steps 3 through 5 for both ALSF-2 and SSALR modes. The adjustments shall manually adjust the normalizer amplifiers to provide a gain between 2 and 8. The bandwidth of the amplifier shall be greater than 700 Hz and less than 900 Hz.

Table VIII. Voltage Ratios (300-watt reference lamp)

Brightness	Ratio
3	0.56 ± 0.02
4	0.37 ± 0.02
5	0.24 ± 0.02

<u>3.2.4.5.2.4. AC to DC converters</u>.- The ac to dc converter shall convert the normalized ac voltage signal into a dc voltage signal equivalent to the true value of the ac signal. The ac to dc converter shall have better than 1 percent accuracy and less than 0.1 percent ripple at or above 60 Hz. The ac to dc converter shall have a gain of one-half.

<u>3.2.4.5.2.5 DC amplifier</u>.- Two dc amplifiers shall be provided to amplify the normalized dc signals. The dc amplifiers shall be linear amplifiers with a fixed gain of 3. The input impedance shall be greater than 3 megohms.

<u>3.2.4.5.2.6 Differential amplifier</u>.- The differential amplifier shall be a linear amplifier and shall amplify the voltage difference between the normalized and amplified loop voltage and reference voltage. The gain of the differential amplifier shall be adjustable from 4 to 45 when the ALS is operated in the ALSF-2 mode and from 3.5 to 10 when the ALS is operated in the SSALR mode. The gain shall be adjusted to output 1 volt for each failed lamp (error voltage). The common mode rejection ratio shall be better than 90 dB. The offset voltage shall be less

than 10 millivolts. The differential amplifier shall have separate adjustments provided for brightness steps 3 through 5 for both ALSF-2 and SSALR modes. The adjustments shall manually adjust the amplifier gain to calibrate the monitor failed lamp output signal for 300 watt lamp (shorted) for a predetermined number of lamps. The accuracy of this signal shall permit detection of failures, as specified in 3.2.4.5. The output signal will be nominally 1 volt per failed lamp for the number of lamps specified for failure detection. The output signal will vary nonlinearly for other numbers of failed lamps dependent on the loop resistance variations.

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3.2.4.5.2.7 Absolute value amplifier.- The absolute value amplifier shall be a linear amplifier with a gain of plus one for positive input signals and minus one for negative input signals. The output signal of the absolute value amplifier shall always be a positive value.

3.2.4.5.2.8 Voltage comparator.- Two identical voltage comparators, each having one volt of hysteresis, shall be provided to detect caution and failure conditions. The output of the voltage comparators shall be TTL compatible and shall be logic high when the input voltage (output of absolute amplifier) is more positive than the latching point. The output voltage shall be logic low when input voltage is mote negative than the reset point. The latching point shall be adjustable between 1 volt dc to 10 volts dc and the reset point shall always be 1 volt dc less than the latching point. The voltage comparator shall drive a light emitting diode, or other similar device, to visually indicate the status of the voltage comparator output. The indicator shall illuminate only when the output of the voltage comparator is logic high and it shall be mounted ont he edge of the circuit module. Voltage comparators shall be provided to detect caution and failure conditions. Each loop shall have adjustments provided to allow detection of the caution and failure conditions in both ALSF-2 and SSALR modes, in accordance with the number of failed lamps specified 3.2.4.5. The adjustments shall be capable of being set to compensate for the nonlinear relationship between the caution and failure detection signals.

3.2.4.5.3 Common electronic circuit.- Common electronic circuitry is required to control and interface the inputs, status, and outputs of the three voltage monitoring channels as shown in figure 9.

3.2.4.5.3.1 Monitor interface circuit.- The switching network interface circuit shall interface input control signals (3.2.4.5.1(c)) and the switching networks (3.2.4.5.2.3) of the three channels. The interface circuit shall receive TTL compatible control signals from the ALS control unit and shall encode them to apply required current and voltage levels to perform the proper switching function of the switching networks of all channels. The interface circuit shall also provide a signal to the voltage dividing networks (3.2.4.5.2.1) and the differential amplifiers (3.2.4.5.2.6) of all channels to select proper gains in the ALSF-2 and SSALR modes.

3.2.4.5.3.2 Inhibit signal generator.- The inhibit signal generator shall generate a logic high inhibit signal for the first 2 minutes (continuously adjustable from 30 seconds to 4 minutes) after:

(a) The regulators are turned on

(b) The brightness setting is changed

(c) The mode is changed

(d) A primary input power surge (momentary power failure)

3.2.4.5.3.3 Alarm signal logic gates.- Two identical alarm signal logic gates shall be provided, one for caution alarm signals and the other for failure alarm signals. Each alarm signal logic gate shall combine three alarm signals, one alarm signal for each channel, such that any logic high input shall result in a logic high output (logic OR). The combined alarm signals shall be inhibited when the inhibit signal, generated in the inhibit signal generator, is logic high, or when the ALS regulators are off. The output of the alarm signal logic gates shall be logic low when all alarm signals are logic low or the ALS regulators are off. Otherwise, the output of the alarm signal logic gates shall be logic high. The output shall meet the output interface requirement in accordance with 3.2.4.5.1(d). In the ALSF mode, the alarm logic shall generate only the ALSF alarm, and in the SSALR mode it shall generate only the SSALR alarm.

3.2.4.5.4 Test panel.- A test panel shall be provided as an integral part of the monitor subsystem for the purpose of calibration and maintenance of the monitor subsystem. The test panel shall consist of a simulator and a voltage indicator. This panel shall be configured and mounted as part of the monitor card cage shown in figures 10 and 11. When a microprocessor is used in the system electronics, a tester board shall be provided for testing the microprocessor board. A diagnostic program shall be provided in plug-in PROM integrated circuits which will be used in place of the system operational program. The tester board shall test the addressing data output, data input, and internal logic operation of the microprocessor. It shall also check the timing and data paths of RAM, PROM, and PAL components located on the processor board. The tester board shall give a visual indication of proper operation of the microprocessor board. The tester board shall be installed in the card rack and be supplied with all interconnecting cables. The diagnostic program software shall be included in the equipment instruction book per paragraphs 3.7.1 and 3.7.2.

3.2.4.5.4.1 Simulator.- The simulator shall be comprised of a switch and six attenuators. In the NORMAL position, the switch shall bypass the attenuators and the loop voltage shall be applied directly to the voltage conditioners. In the ALSF-2 TEST position, the attenuators shall be connected in series with the loop voltage input lines. The attenuators in the ALSF-2 mode, shall attenuate the loop voltage to simulate five (adjustable from 1 to 10) failed lamps in each current loop. In the SSALR TEST position, the attenuators shall simulate two (adjustable form 1 to 4) failed lamps in each current loop. The six attenuators shall be calibrated for a predetermined brightness step for both ALSF-2 and SSALR modes. The number if failed lamps simulated for other brightness steps will be a nonlinear function depending on the loop resistance variations.

3.2.4.5.4.2. Voltmeter.- The voltmeter shall be a small (approximately 3 inches (76 mm) per side) rectangular panel type voltage indicating instrument in accordance with ANSI standard C39.1. The meter shall be a dc voltmeter to measure voltages between -15 volts and +15 volts. The panel shall be marked 1 volt per lamp to indicate the number of failed lamps at 1 volt per lamp. When the meter selector switch is in the VM position, the meter input shall be connected to a test jack on the panel. Full scale accuracy shall be better than 3 percent. Input impedance of the voltmeter shall be greater than 15 kilohms per volt. A panel-mounted selector switch shall be provided to select the error voltage (3.2.4.5.2.6) from each of the channels.

3.2.5 Flashing lights subsystem.- The flashing light section of the ALSF-2 system will consist of a maximum of 21 flashers for a 3,000 feet (914 meters) ALS, and a minimum of 15 flashers for a 2,400 feet (732 meters) ALS. The flashing light section of the SSALR system will consist of a maximum of 8 flashing for a 3,000 feet (914 meters) ALS and a minimum of 5 flashers for a 2,400 feet (712 meters) ALS. The flasher subsystem shall consist of a flasher master controller unit, junction boxes, and flasher assemblies. Flasher assemblies may be either elevated (Type I) or semiflush (Type II). Upon receiving a command either from the ATCT or the master controller (3.2.5.1), the sequenced flasher light units shall produce a flashing light signal having the appearance of a flash traveling down the ALS from the flasher farthest from the runway threshold to the flasher closest to the runway threshold twice

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